

PSYC 305 Lecture 2

- Agenda
 - Quiz
 - Experimental methods

Quiz 3

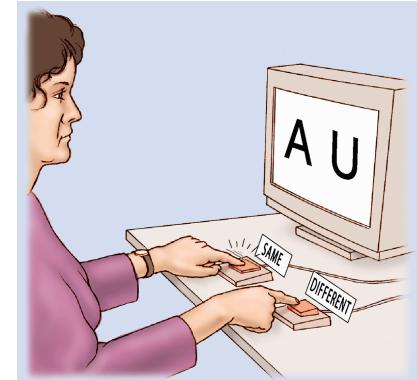
1. What carries the neurotransmitters to the cell wall of the presynaptic terminal?
 - a. Vesicles
 - b. Glial cells
 - c. Receptors
 - d. Dendrites
2. The _____ is the input to a neuron and the _____ is the ou
 - a. Axon, dendrites
 - b. Dendrites, axon
 - c. Soma, axon
 - d. Axon, soma
3. What is fMRI?
4. If you wanted to test how quickly you can perceive a flower, what method(s) could you use?

Methods

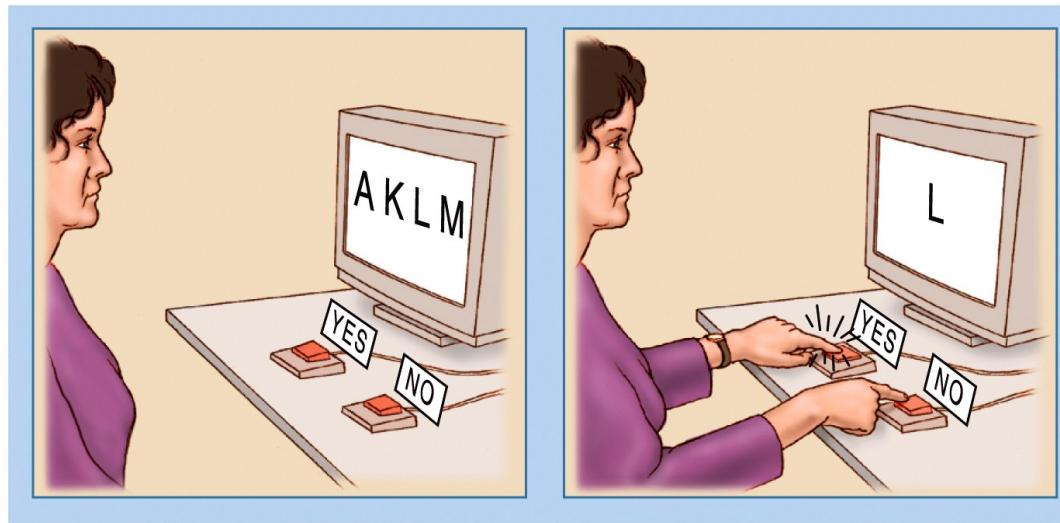
- Behavioral paradigms
- Case studies
- Brain stimulation
- Brain imaging

Behavioral paradigm - Cognitive Psychology

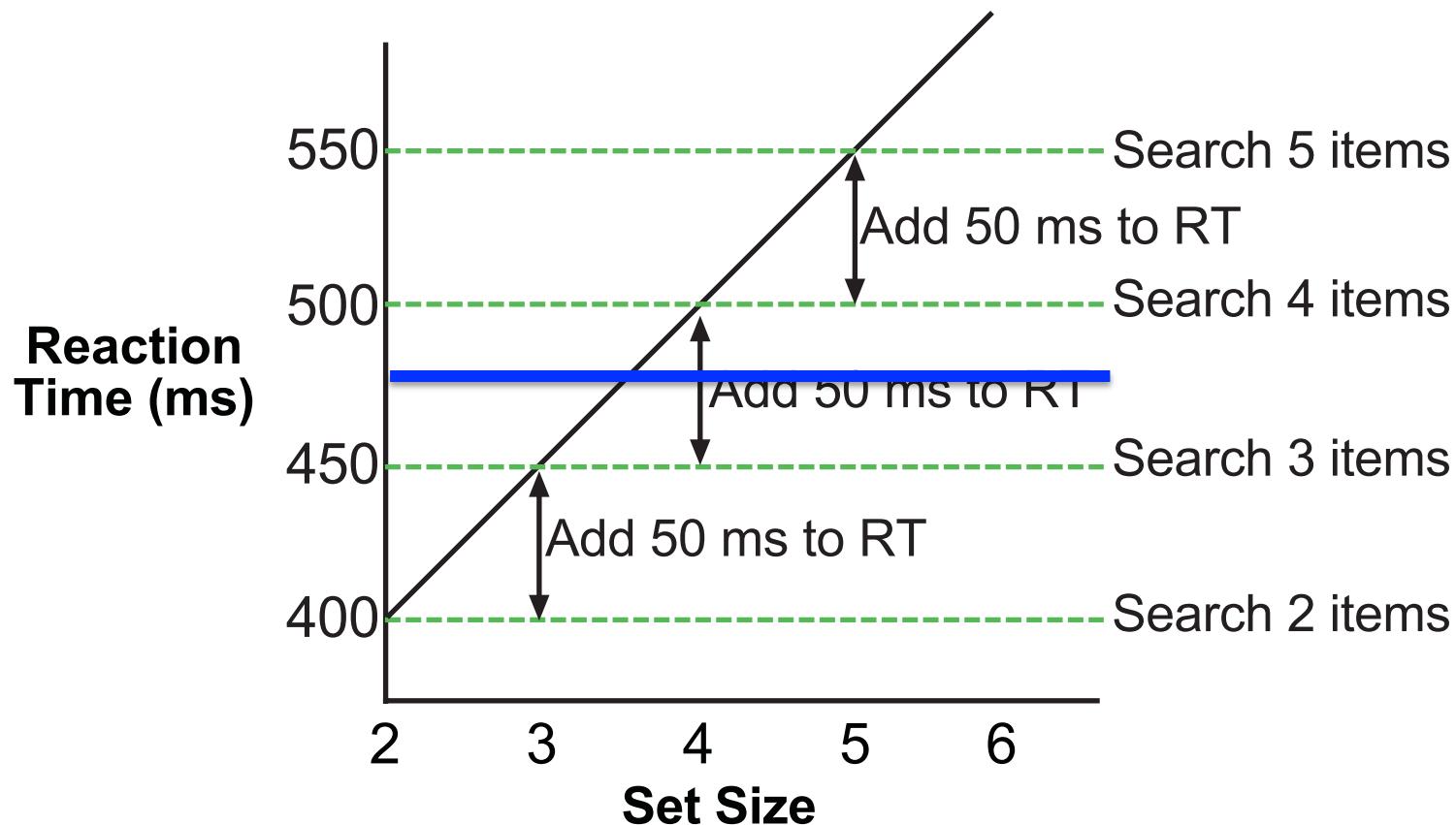
- Goal: Provide detailed description of behavior (thinking, acting) based on how information representations are stored and processed.
- Approach: Give subjects a controlled cognitive task and measure performance
 - Response times (RTs)
 - Accuracy
 - Eye-movements
- Compare performance under different conditions

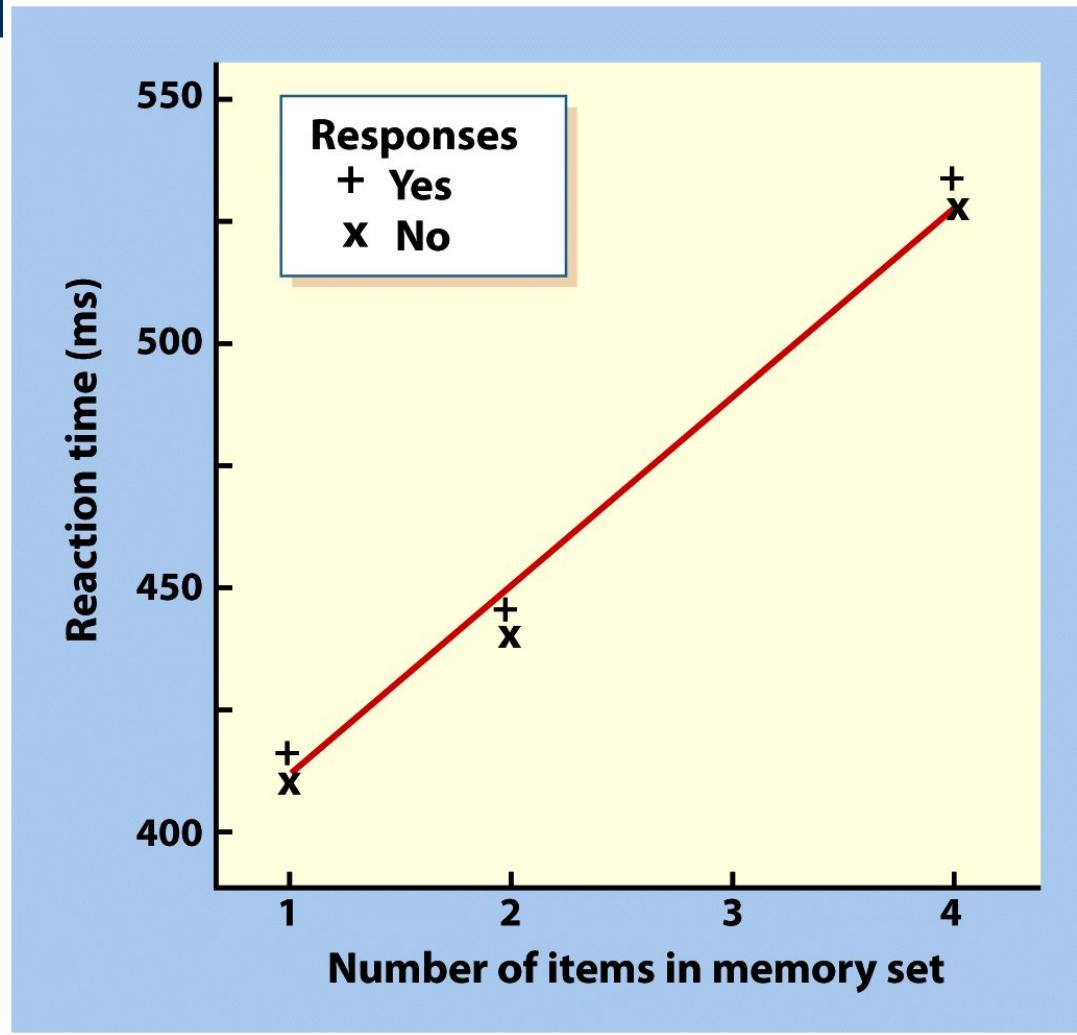


Evidence for serial processing: Sternberg short-term memory experiment



RT goes up by 50 ms for each item added to the array
(Slope = 50 ms/item).





Conclusions: memory items are scanned serially and exhaustively during memory search

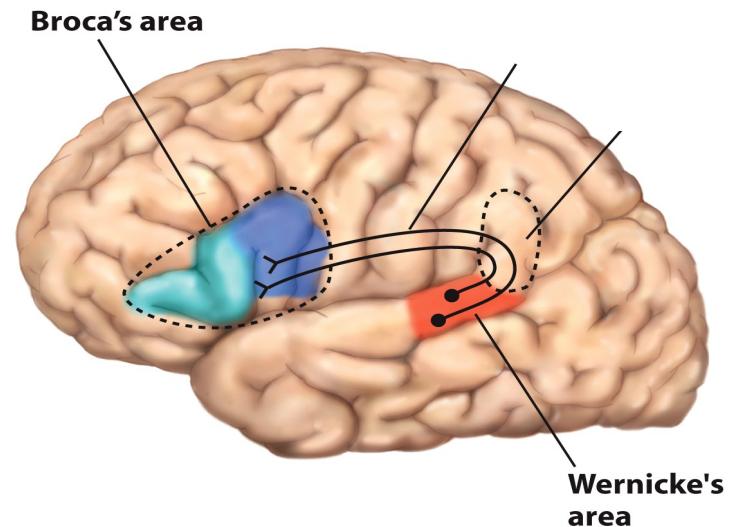
Behavioral paradigms (cog psych)

Strengths	Weaknesses
Tests units of representations and consequences of manipulation processes (e.g. serial versus parallel memory search).	Cannot see how processes and representations are implemented; mechanisms inferred from behavior
Detailed models of relationship between inputs (sensory stimulation, instructions, environment) and outputs (behaviors, thoughts, actions). Provides experimental design and gives names to component functions.	Need overt responses
Can ask complex questions of awake, behaving humans.	

Case studies

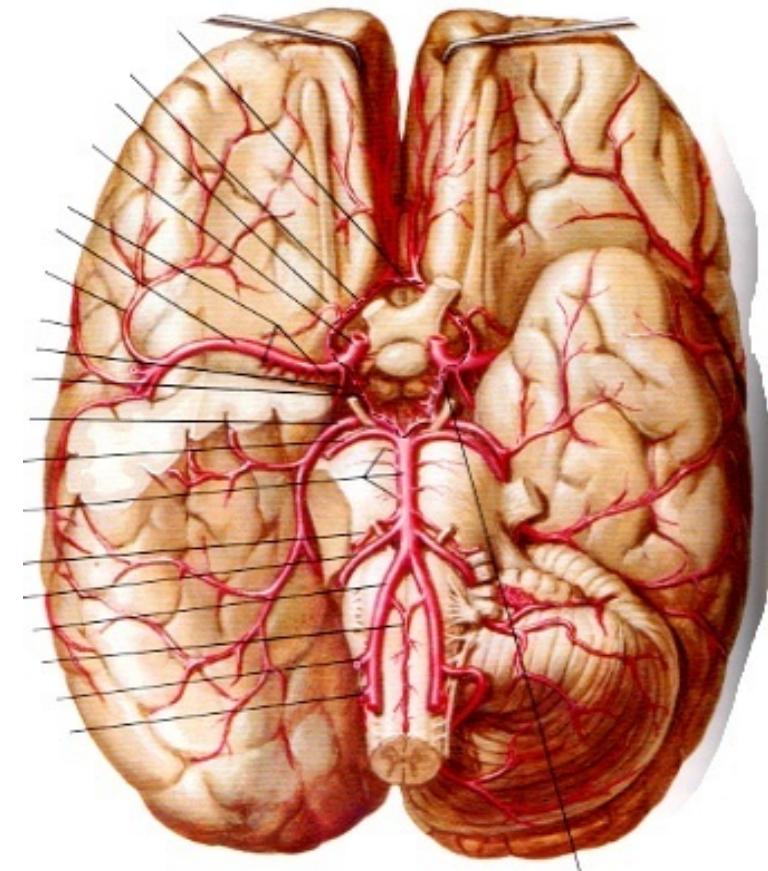
➤ Jargon

- Lesion – any damage to the brain
- Necessary versus sufficient
 - Lesion in Broca's area leads to a deficit in language production
 - Necessary, but is it sufficient?



Case studies

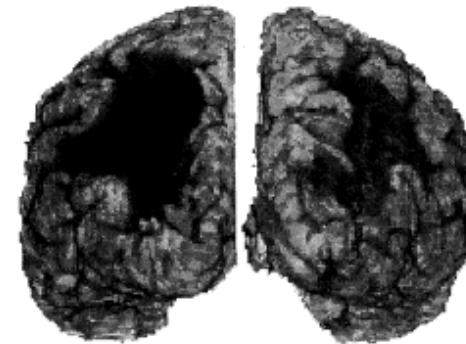
- Test whether a particular brain region is *necessary* for a cognitive function
- Common causes of lesions in humans:
 - Stroke, cerebral hemorrhage, aneurism, anoxia, etc.
 - Head injuries
 - Tumors and their surgical removal
 - Alzheimer's disease, etc.



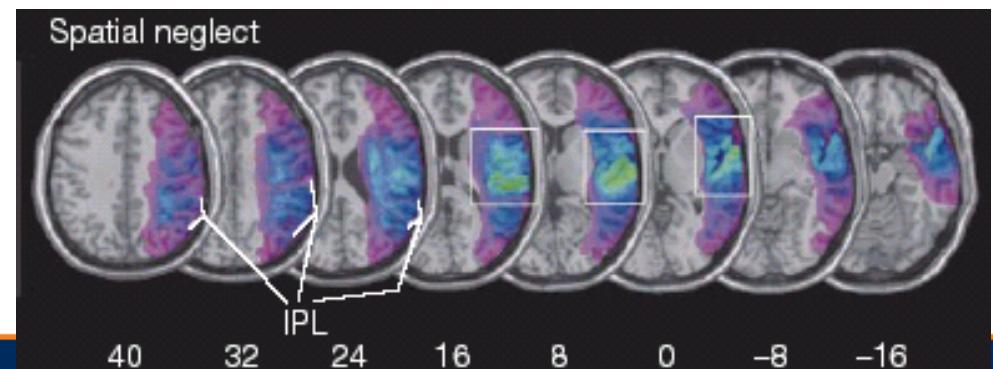
Neuropsychology

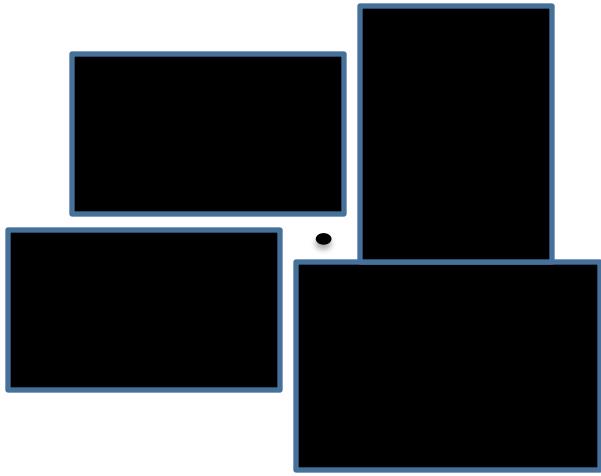
Establish nature of impairments following focal lesions: Look for dissociations between impaired and spared cognitive processes

Case studies



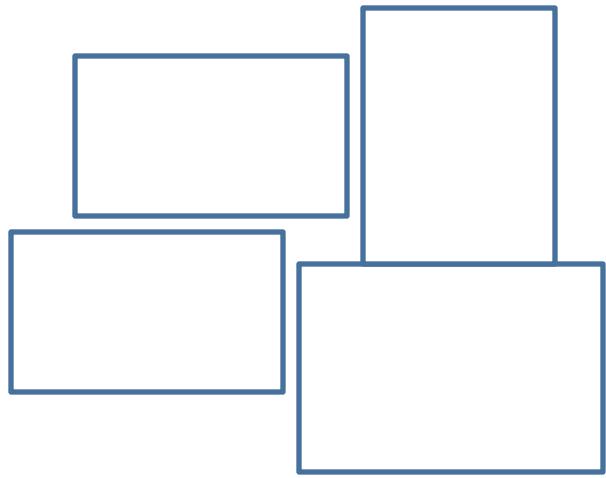
Group studies (area of overlap)





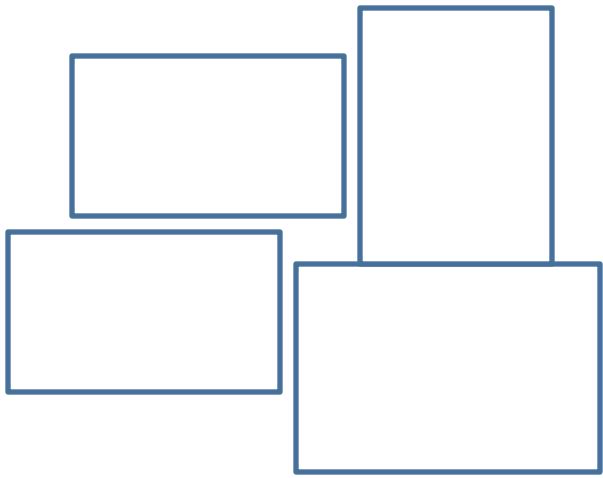
Remember animals and locations:

- object versus spatial memory



Where were was the giraffe located?
(spatial)

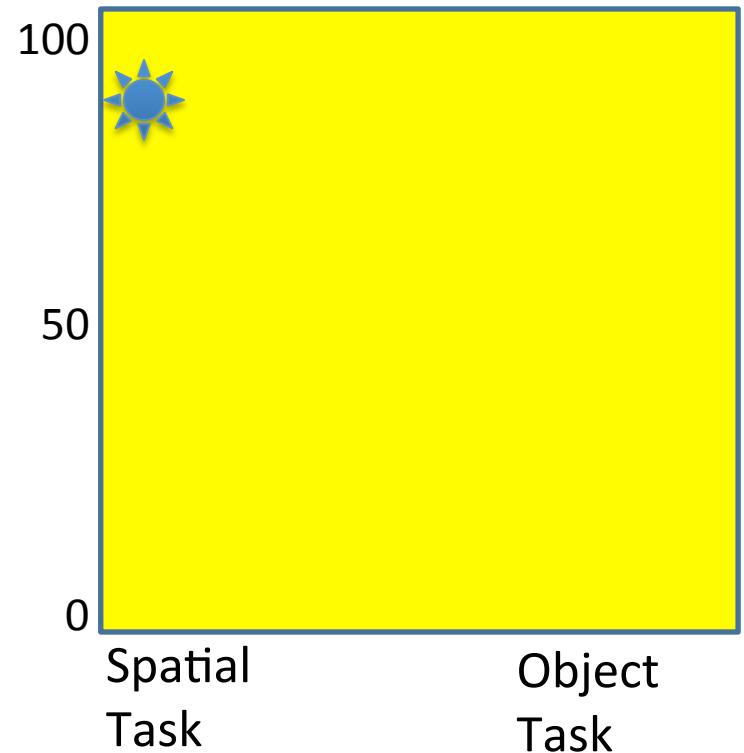




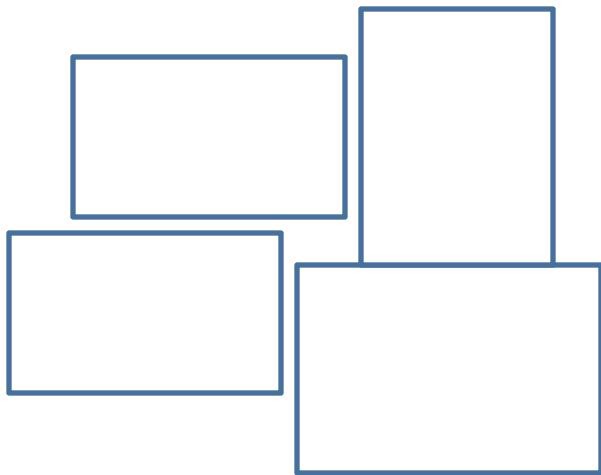
Where were was the giraffe located?
(spatial)



% correct



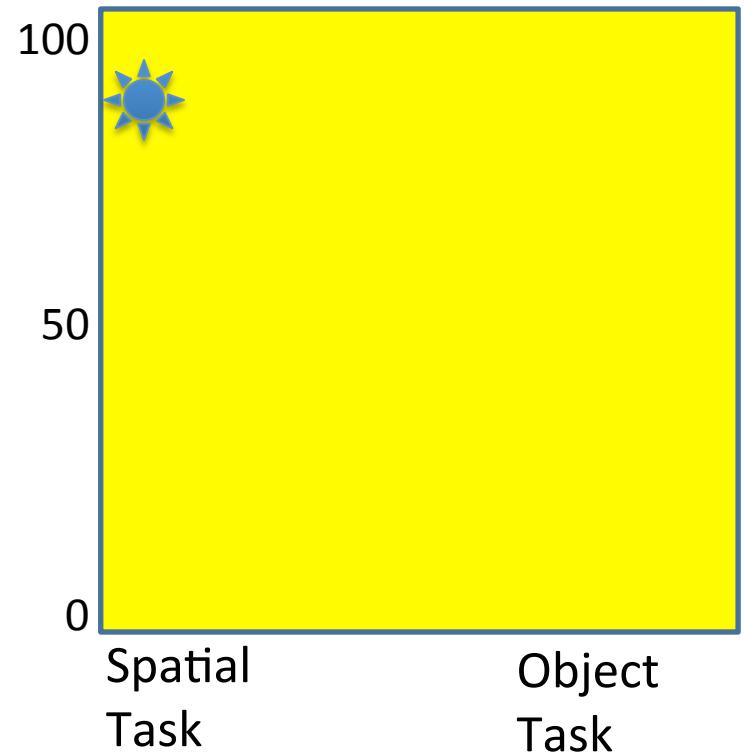
Single dissociation



Where were was the giraffe located?
(spatial)

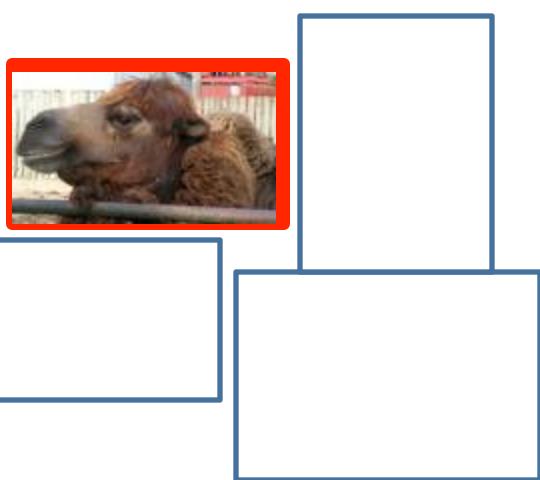


% correct

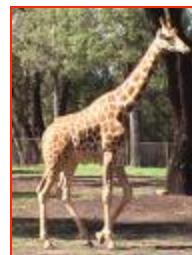


Single dissociation

Is object information stored in the temporal lobes?

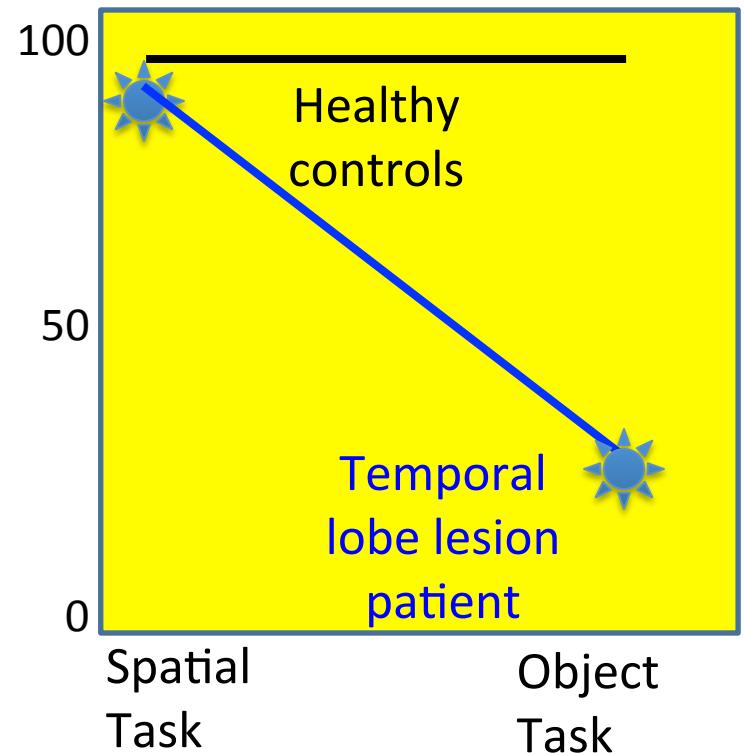


Where were was the giraffe located?
(spatial)



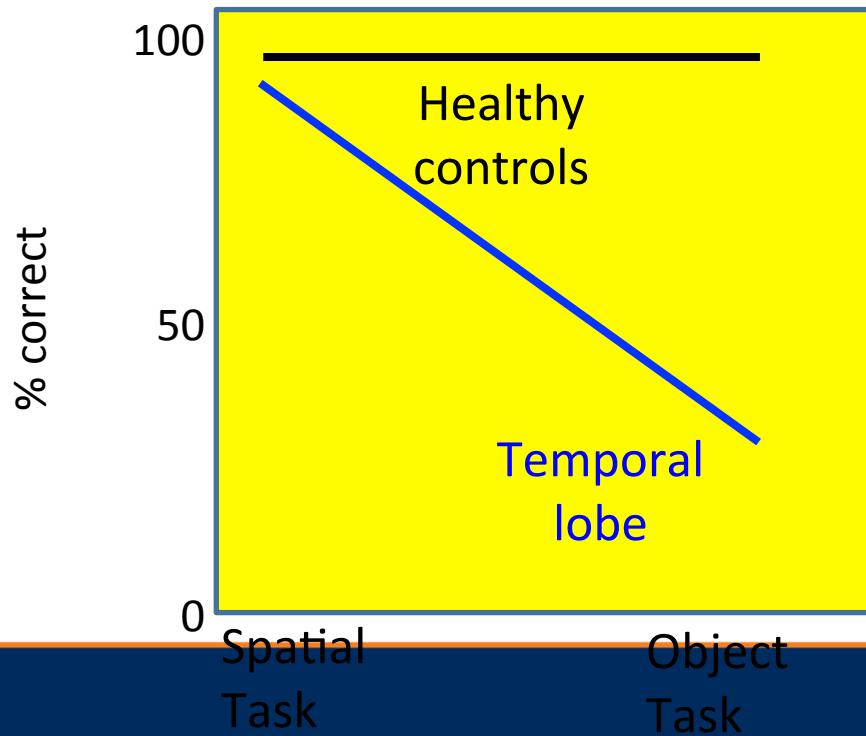
Did you see a camel? (object)

% correct

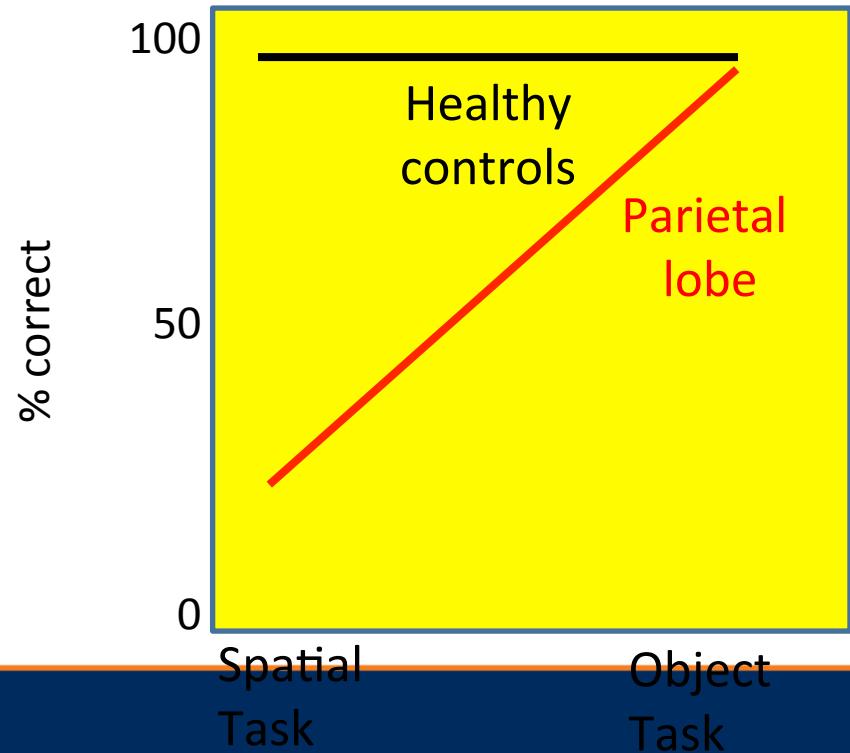
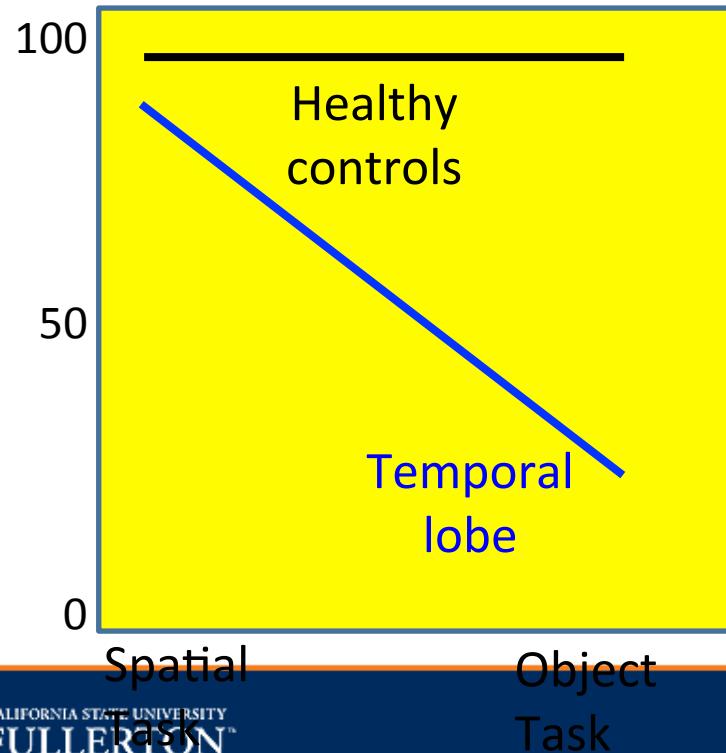


Is spatial task too easy for everyone?

- Problems with single dissociation
 - Is the object task simply harder to score because there are more possible answers?
 - Does patients fail the object task due to general effect of brain damage (e.g., same deficit from other brain lesions)?



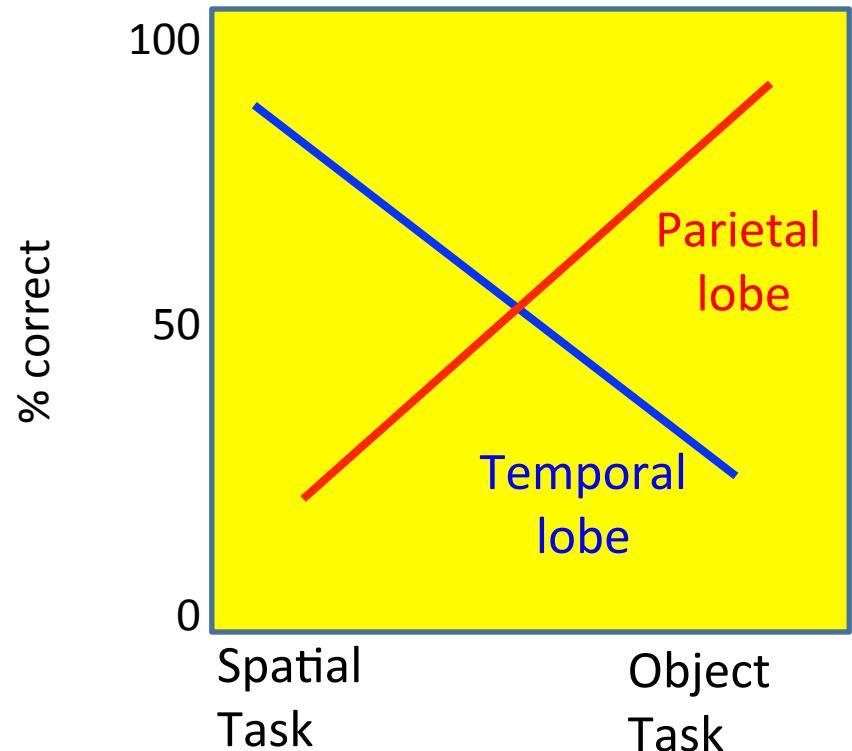
Double dissociation



Double dissociation

Cross-over

Cross-over interaction shows independence in process is not due to un-controlled experimental factors



Lesions, brain stimulation, brain imaging of a brain area

	Function C	Function D	
Brain area A lesion	X	✓	Single dissociation
Brain area B lesion	✓	X	Single dissociation

Together – double dissociation

Lesions, brain stimulation, brain imaging of a brain area

	Function C	Function D	
Brain area A Lesion	X	✓	Single dissociation
Brain area B Lesion	X	✓	Single dissociation

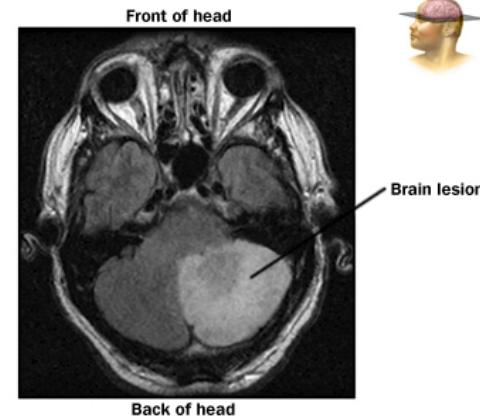
*Together – two single dissociations
NOT a double dissociation*

Lesions, brain stimulation, brain imaging of a brain area

	Speech Production	Speech Comprehension	
Broca's area	X	✓	Single dissociation
Wernicke's area	✓	X	Single dissociation

Together – double dissociation

- Damage is often wide spread
- Neural plasticity may mask deficit
- Deficit could be due to connection



Neuropsychology

Strengths	Weaknesses
Powerful method for determining whether a region is necessary for a cognitive function.	Human lesions are rarely restricted to a single area, so inference for anatomical correlate is often weak (Group studies are hard b/c patients differ).
Compelling (fairly causal).	Neural plasticity/ compensatory strategies could mask a cognitive deficit.
	Don't know if damaged region is of primary or secondary importance for function (connectivity).(i.e., whether or not it is sufficient for the function).

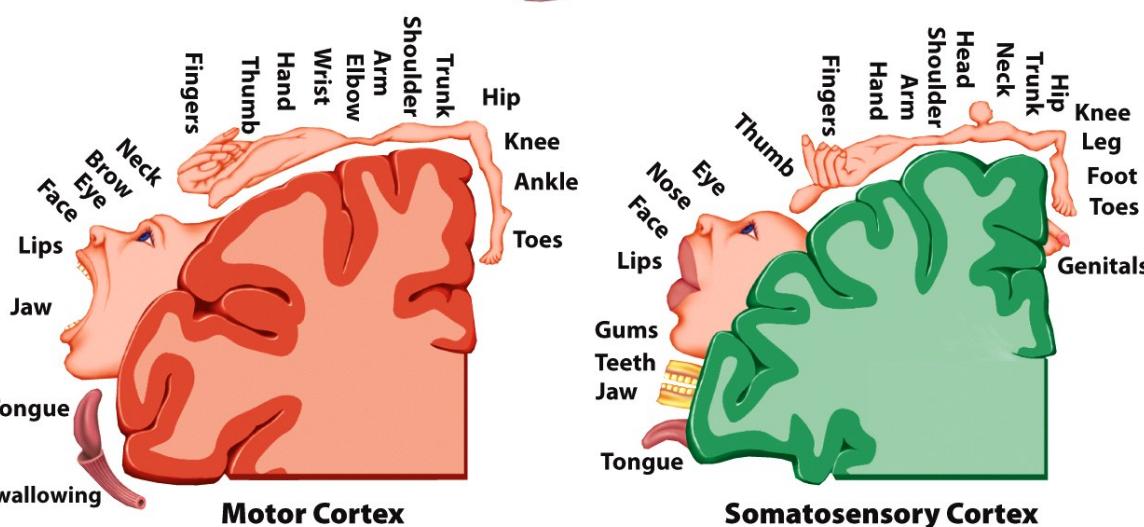
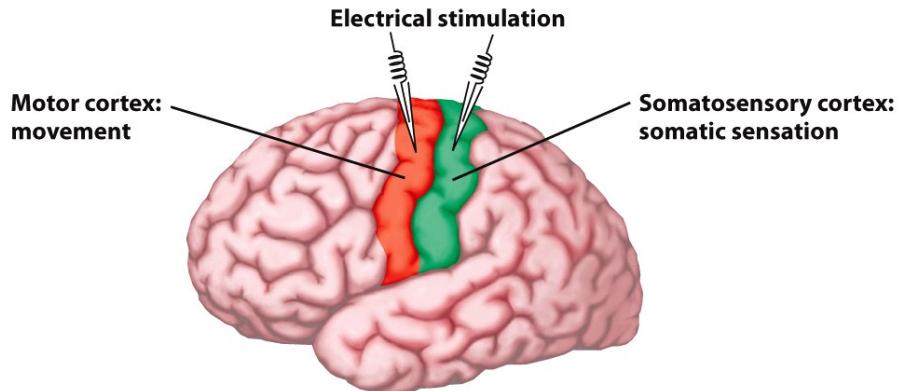
Animal Lesions

- Lesions can be created anywhere in animals and with great precision
 - Permanent lesions (e.g., chemical)
 - Reversible lesions (e.g., cooling)

Strengths	Weaknesses
Precise area/ type of damage	Inference to human cognition/ anatomy unclear.
Lesions can be anywhere	



Invasive brain stimulation



Somatosensory homunculus

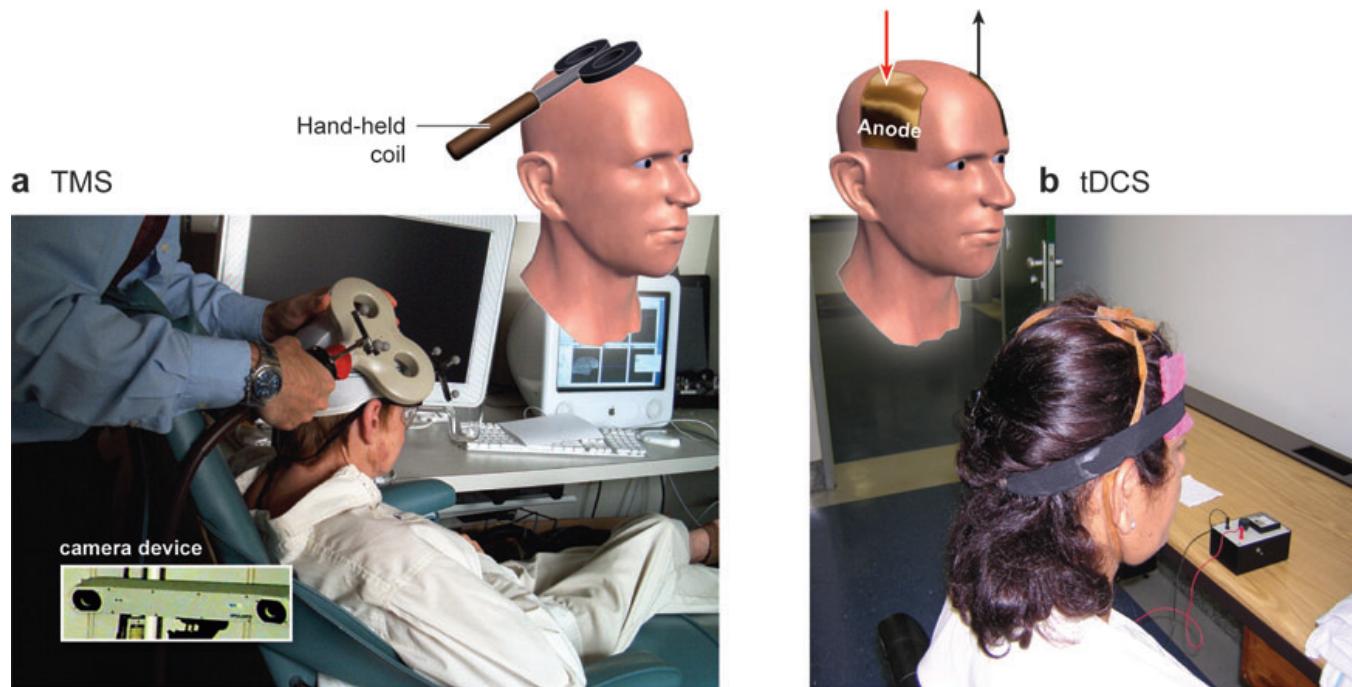


Invasive brain stimulation

Strengths	Weaknesses
Precise temporal and spatial stimulation	Invasive
See direct and “downstream” effects of regional activity	
Causal relationship	

Non-invasive brain stimulation (NIBS)

TMS & tDCS



Causal inference – if I mess with this brain region, it causes in a difference

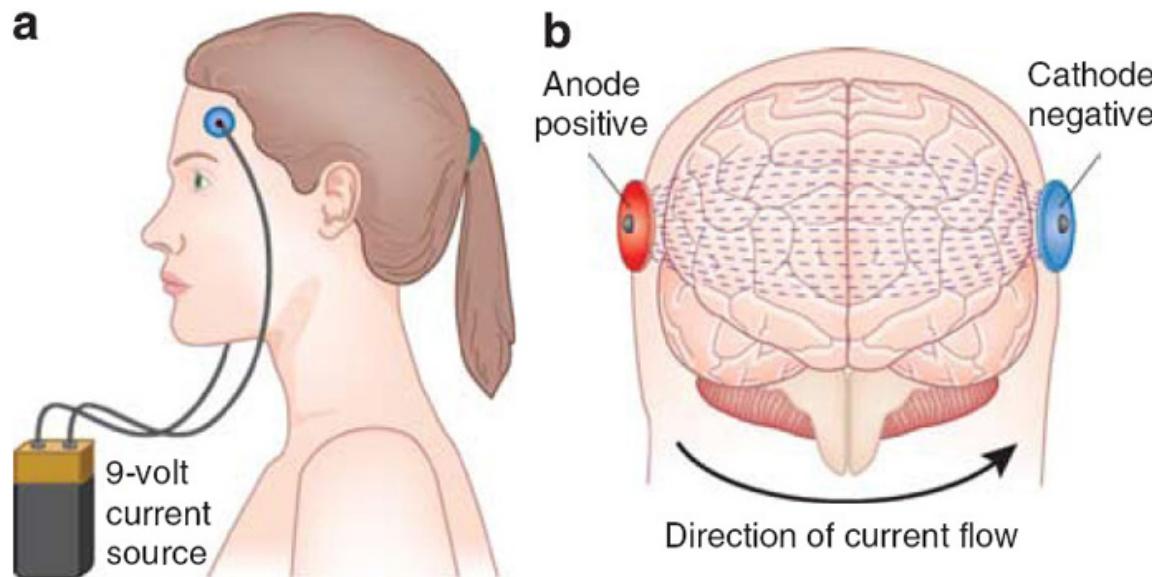
Transcranial magnetic stimulation (TMS)

- Shallow – only reaches a few cm into brain
- Local – pulse is highly localized to what you are aiming at



Transcranial direct current stimulation (tDCS)

- Deep – stimulation can reach deep brain structures
- Non-local – stimulation hits many brain areas at once



TMS and tDCS in humans

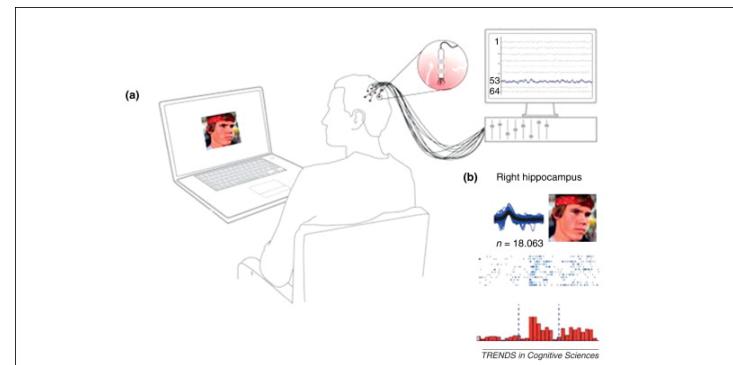
Strengths	Weaknesses
Good temporal resolution: as fast as 20 ms (single TMS pulse)	Limited to surface of brain; area activated depends on tilt of coil, placement of electrodes and physical topography of brain (individual differences)
Short term stimulation (~15 min) with long lasting effects	
Spatial precision: diff. effects for sites 1-1.5 cm apart	Mechanisms of stimulation vs. disruption not totally understood
Non-invasive	
Find <i>causal</i> relationship	

Methods

- Brain imaging
 - Temporal resolution – precision in *time*
 - High temporal resolution - know exactly *when* something happened (ms range)
 - Spatial resolution – precision in location
 - High spatial resolution - know exactly *where* something happened (mm range)

Imaging

- Single-cell recordings



- EEG

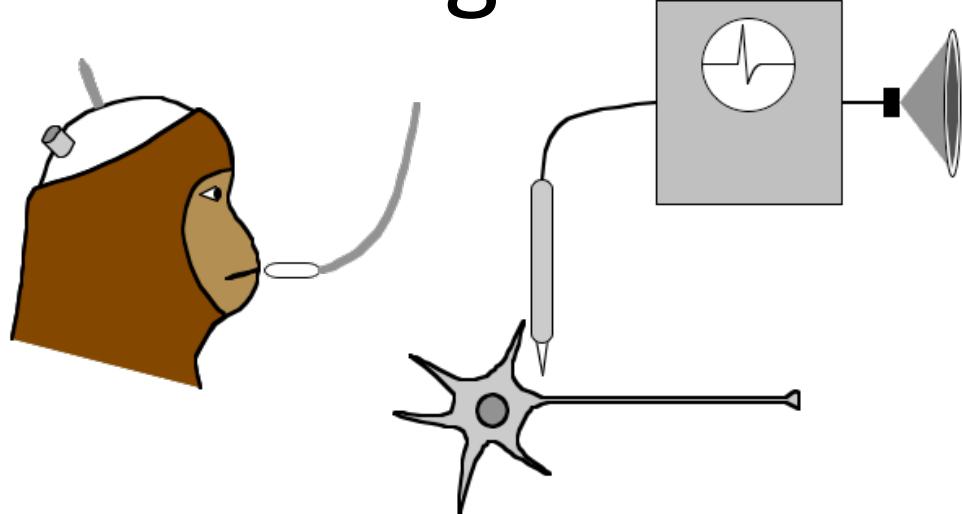
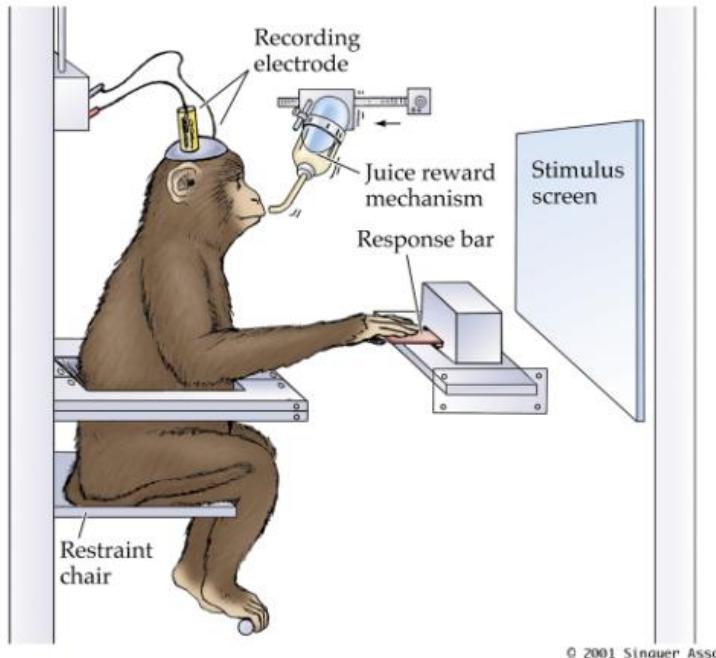


- fMRI

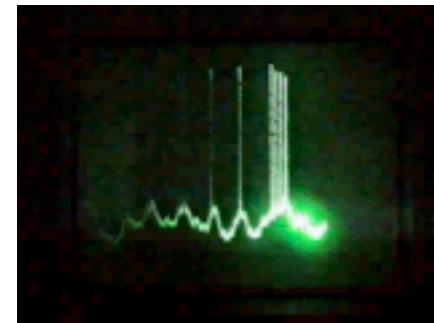


Single unit recording

Measures response properties
of neurons under different
experimental conditions



Tip of electrode just outside cell body: record (listen without poking cell)



High spatial and high temporal resolution

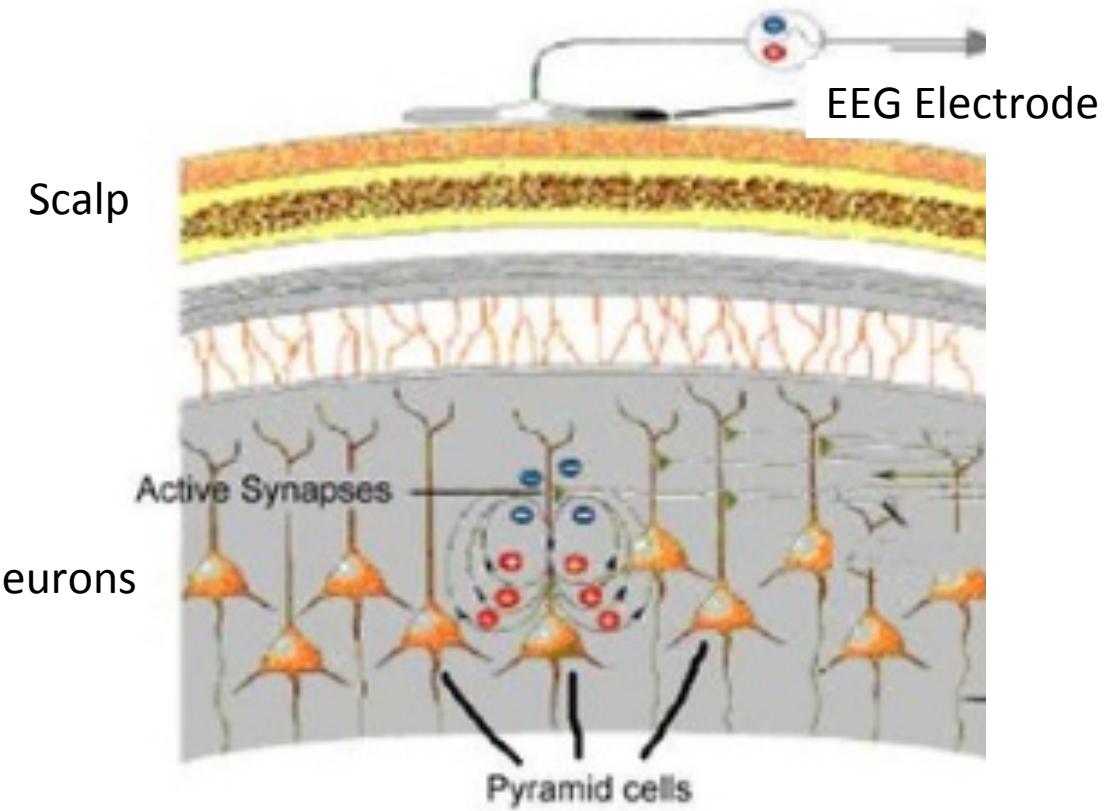
Single-Cell Recording

Strengths	Weaknesses
Powerful method for examining fundamental units of information processing.	Hard to examine interactions between brain areas.
Spatial and temporal precision.	Animals highly overtrained.
	Fairly inaccessible in humans.

The Electroencephalogram (EEG)

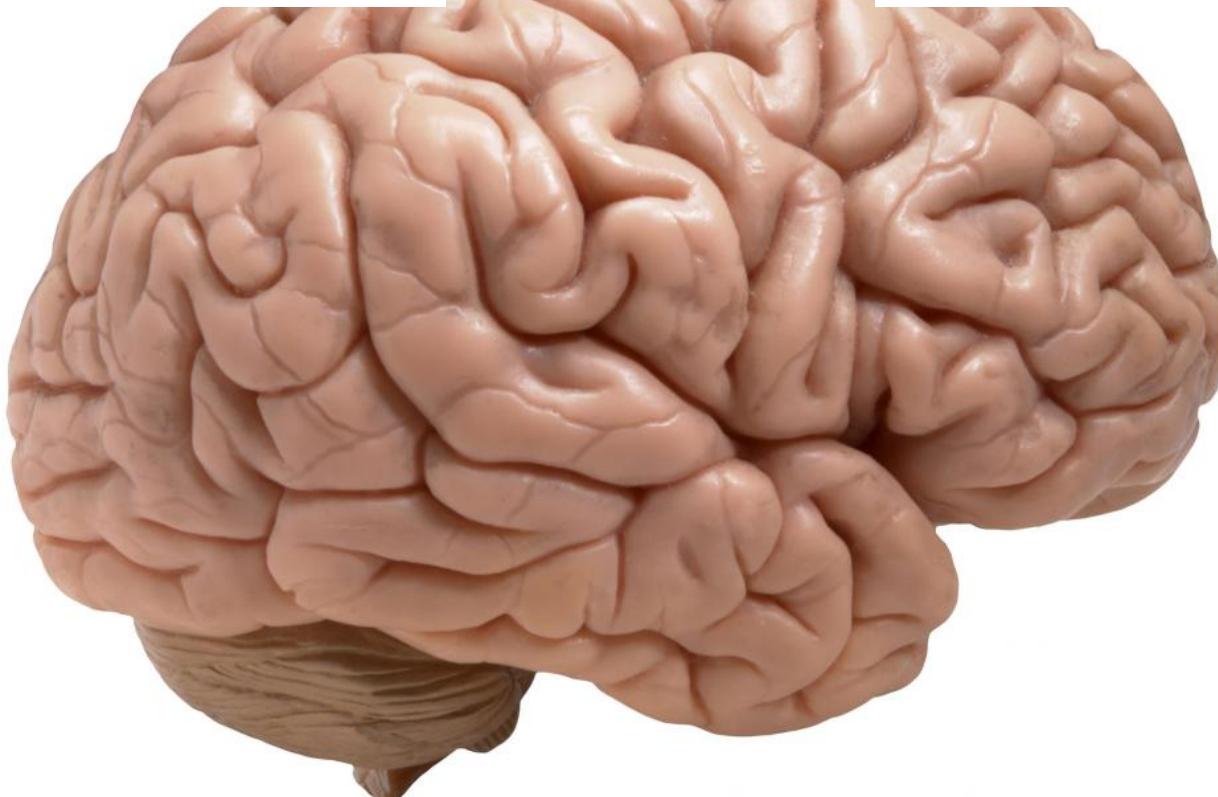


Measures changes in electric field potentials caused by neural activity

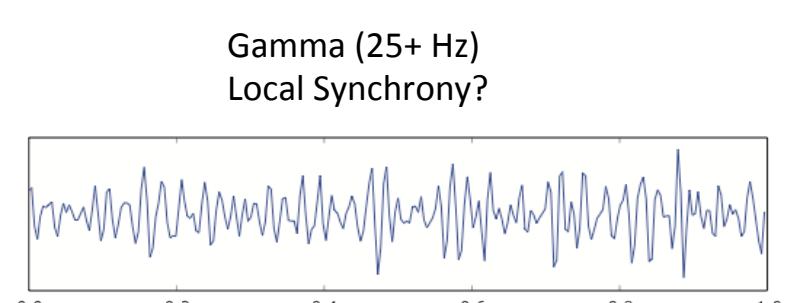
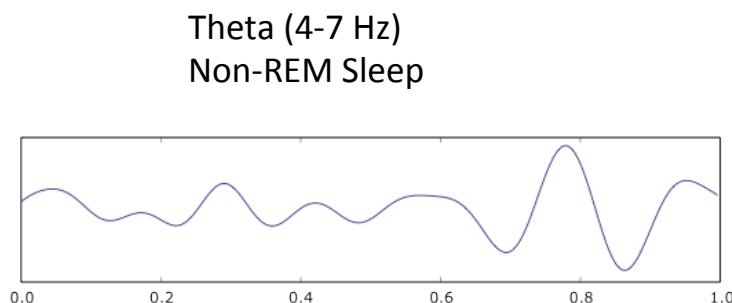
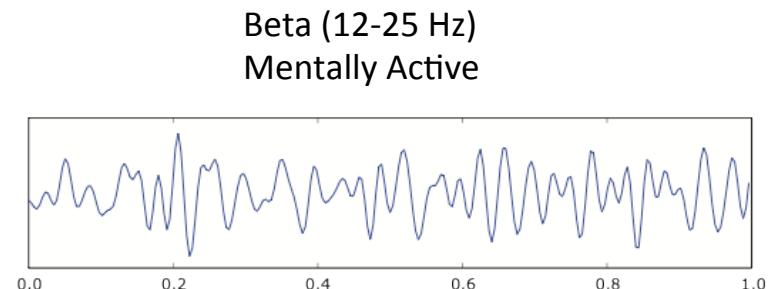
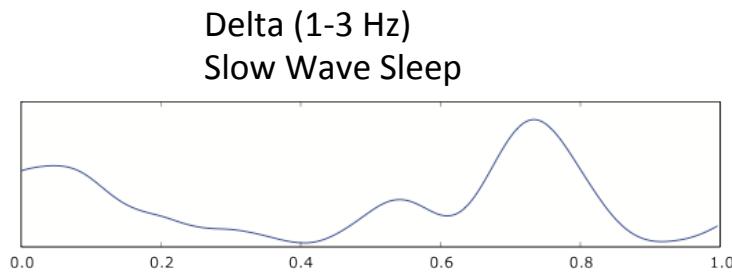
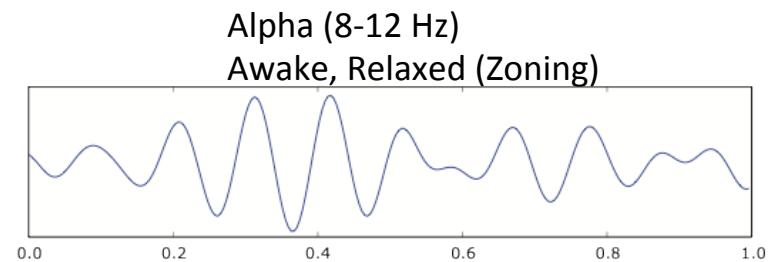
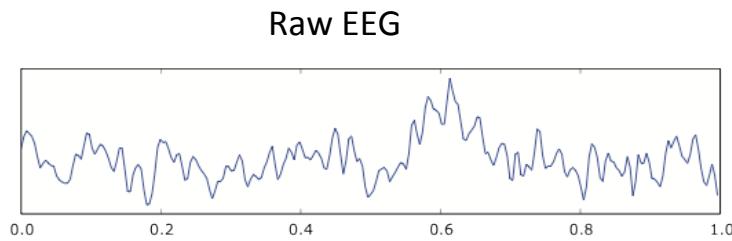


High temporal resolution
Low spatial resolution

Brain oscillations



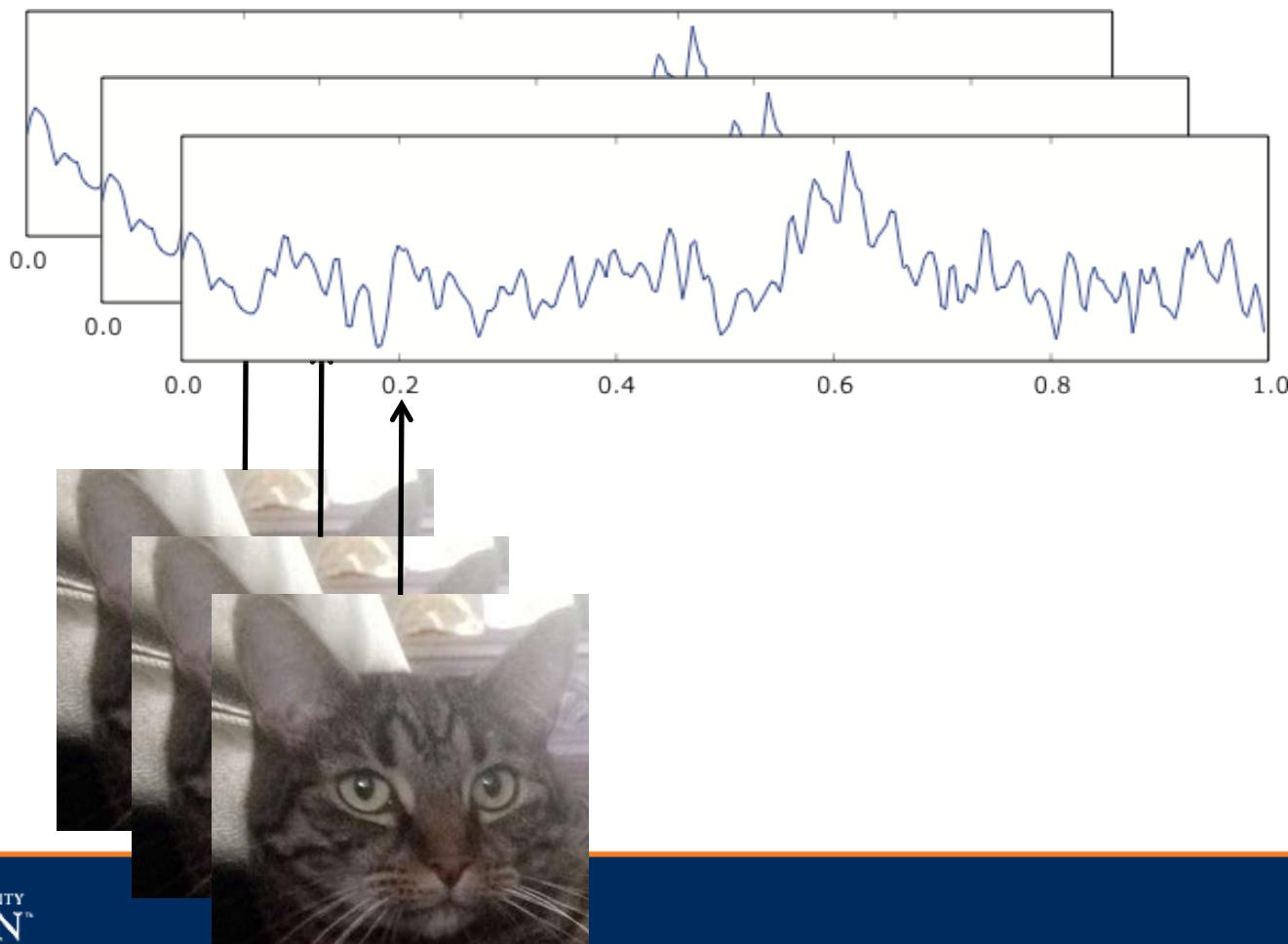
Basic EEG



EEGs reflect overall brain activity

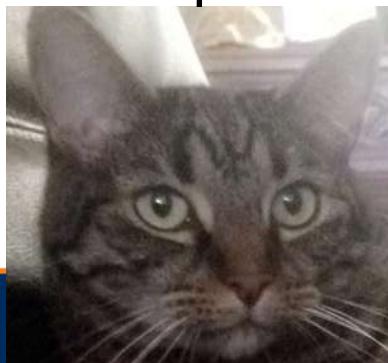
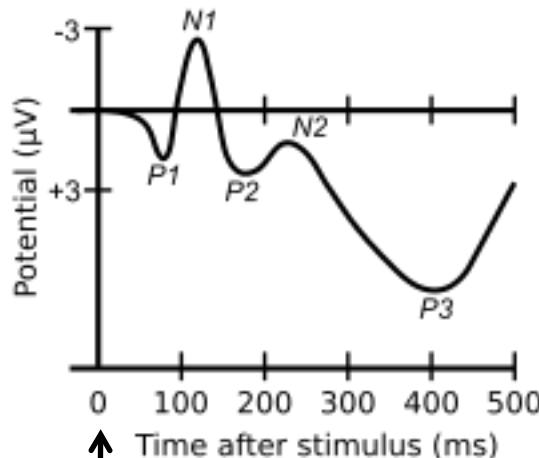
Event-related potential (ERP)

- Averaged EEG in relation to an event (see pic)



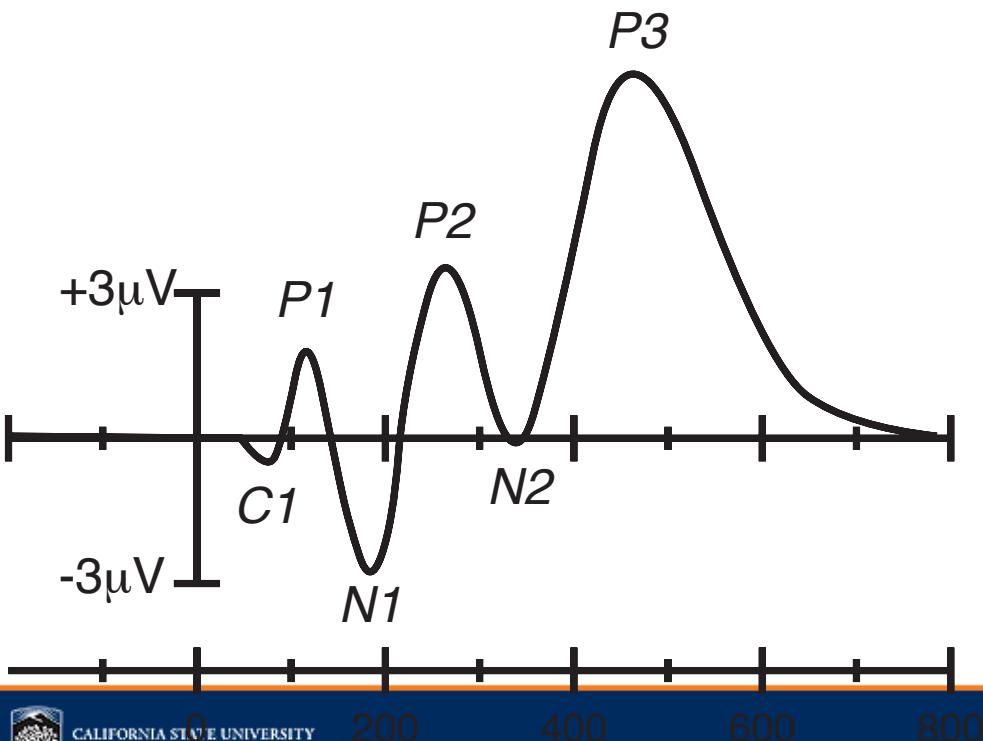
Event-related potential (ERP)

- Averaged EEG in relation to an event



Peaks and Components

- An ERP waveform contains several peaks
- Peaks correspond to underlying cognitive processes

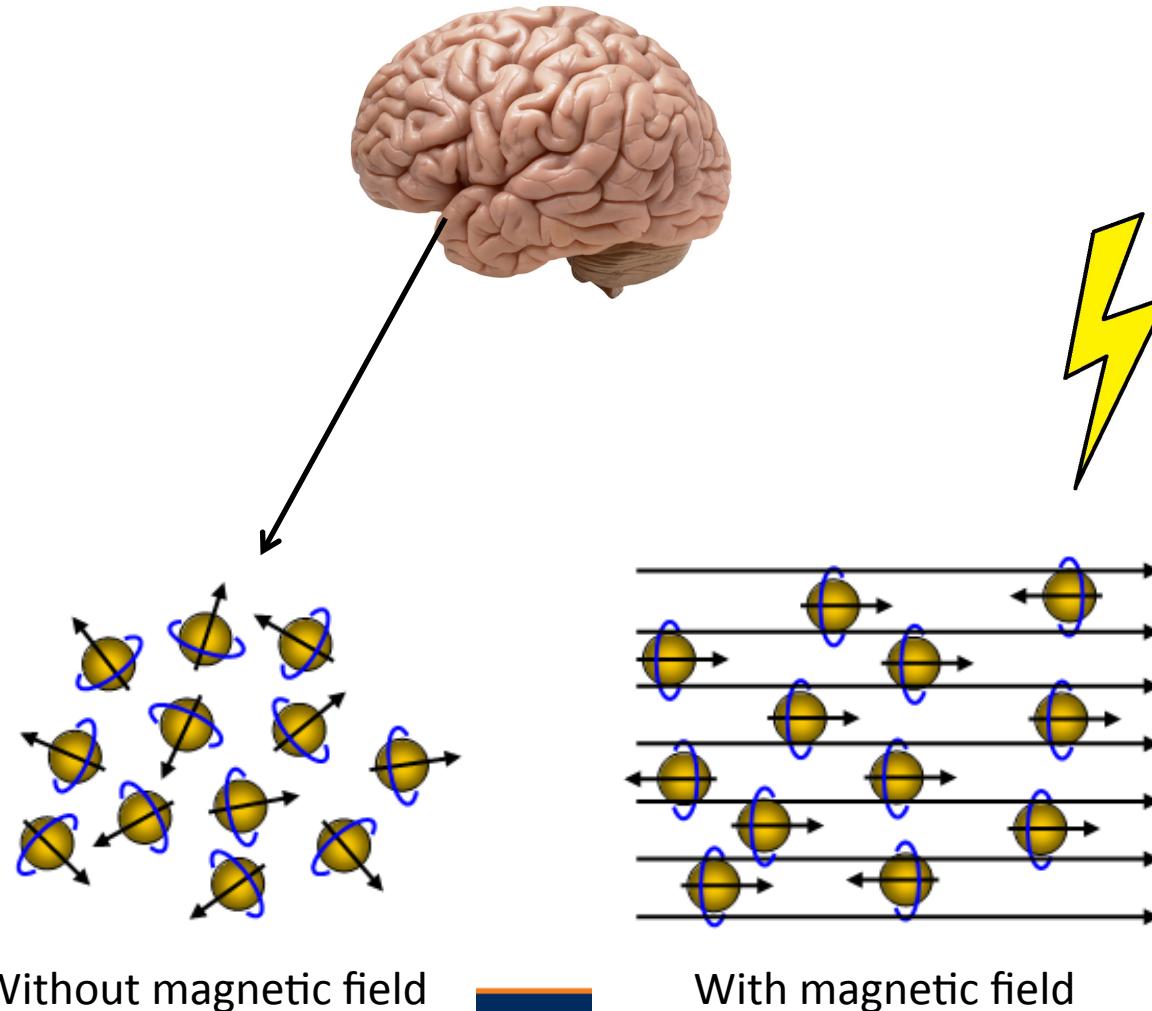


Names are largely descriptive:
P1 – positive wave at 100ms
N2 – negative wave at 200ms

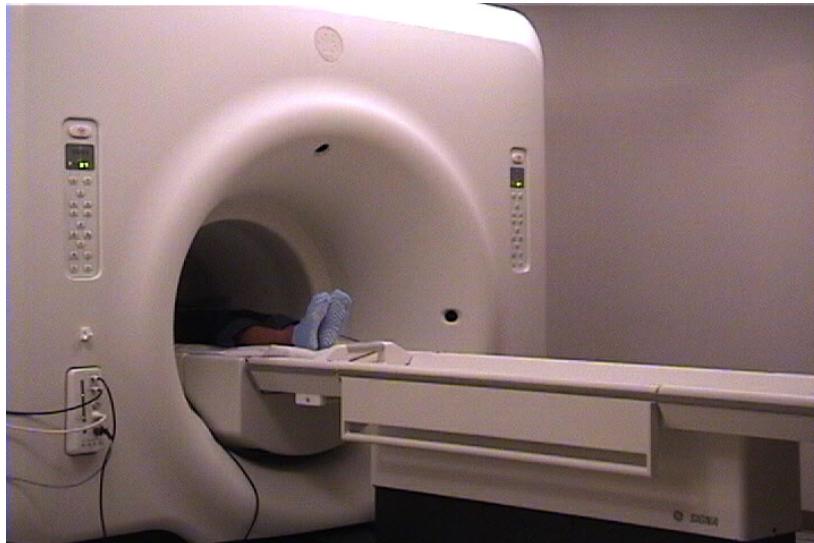
EEG

Strengths	Weaknesses
Temporally precise activity related to neural signal underlying cognitive process	Measure large populations of neurons due to diffusion of electrical signal by skull
Non-invasive	Localizing source of signal is hard
	Need to average a lot of events to get clear event-related potential

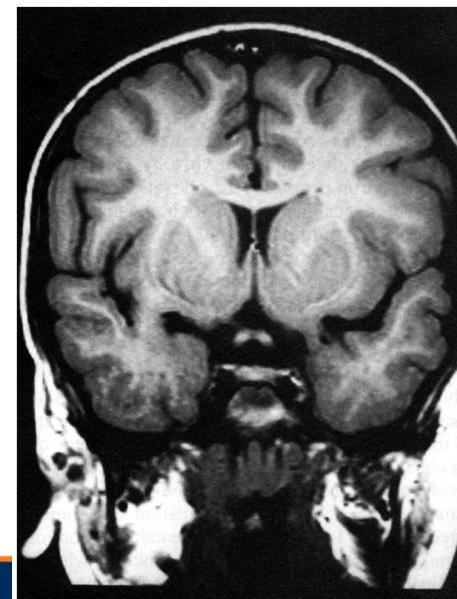
Magnetic Resonance Imaging (MRI)



Magnetic Resonance Imaging (MRI)

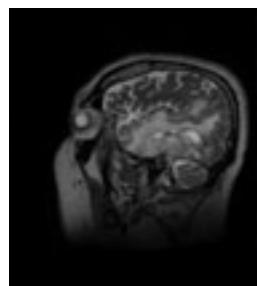
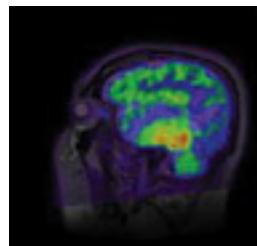
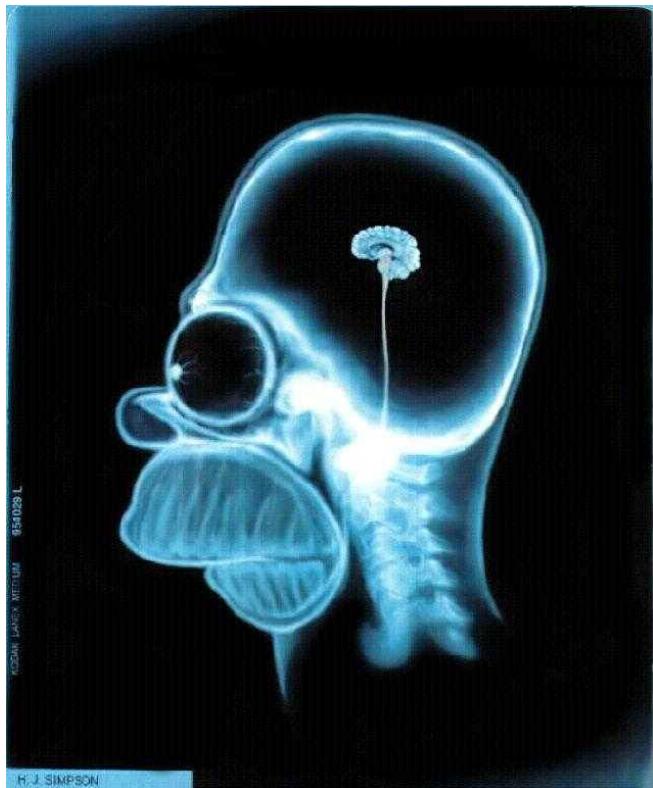


- strong magnetic field
- protons in the brain align with magnetic field
- radio wave perturbs alignment in “slice”
- detectors pick up the signal of protons returning to orientation of magnetic field
- different tissues have diff densities of protons and relaxation rates

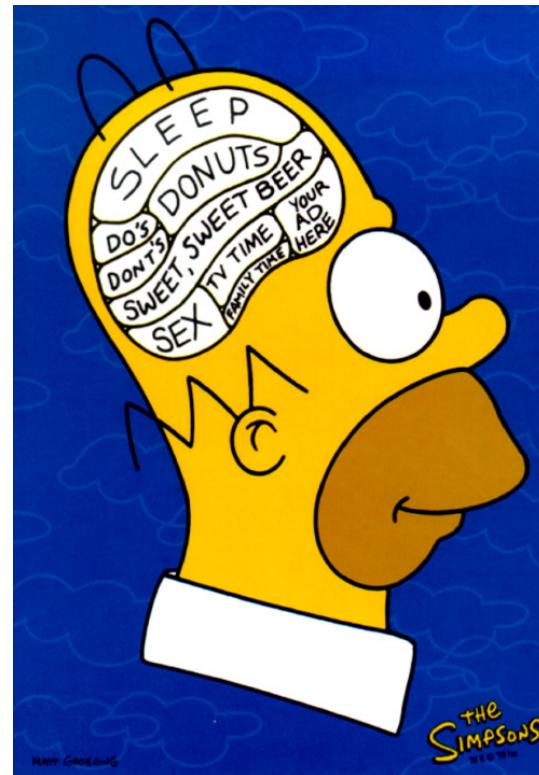


Magnetic resonance imaging (MRI): structural and functional

MRI (or 'structural MRI')
studies brain anatomy.



Functional MRI (fMRI) studies
brain function



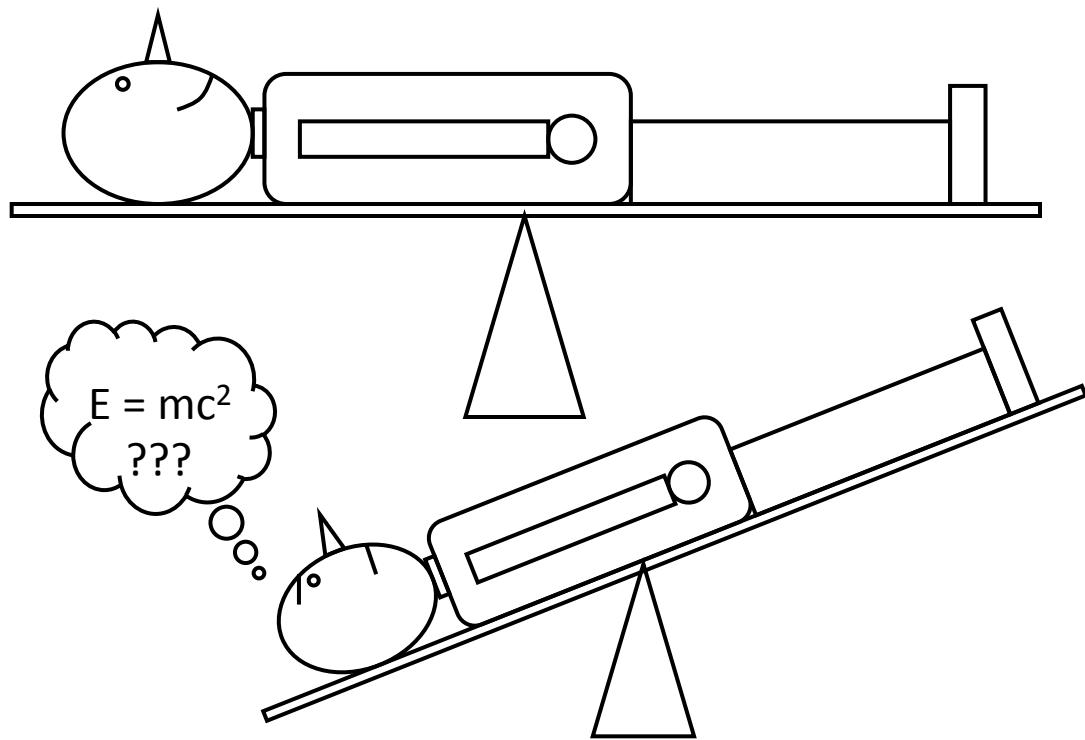
How to get this assuming no direct way of measure neuronal activities?

Indirect: "light up" – energy consumption by refrigerator light

The First Functional “Brain Imaging”



*Angelo Mosso
Italian physiologist
(1846-1910)*

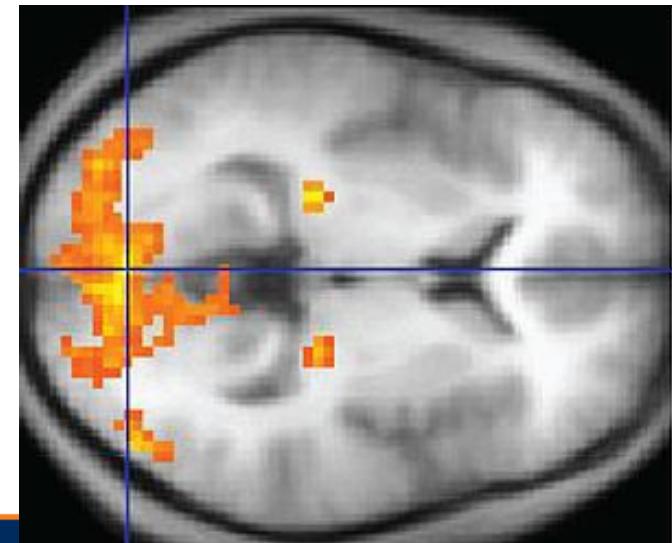


“[In Mosso’s experiments] the subject to be observed lay on a delicately balanced table which could tip downward either at the head or at the foot if the weight of either end were increased. The moment emotional or intellectual activity began in the subject, down went the balance at the head-end, in consequence of the redistribution of blood in his system.”

-- William James, *Principles of Psychology* (1890)

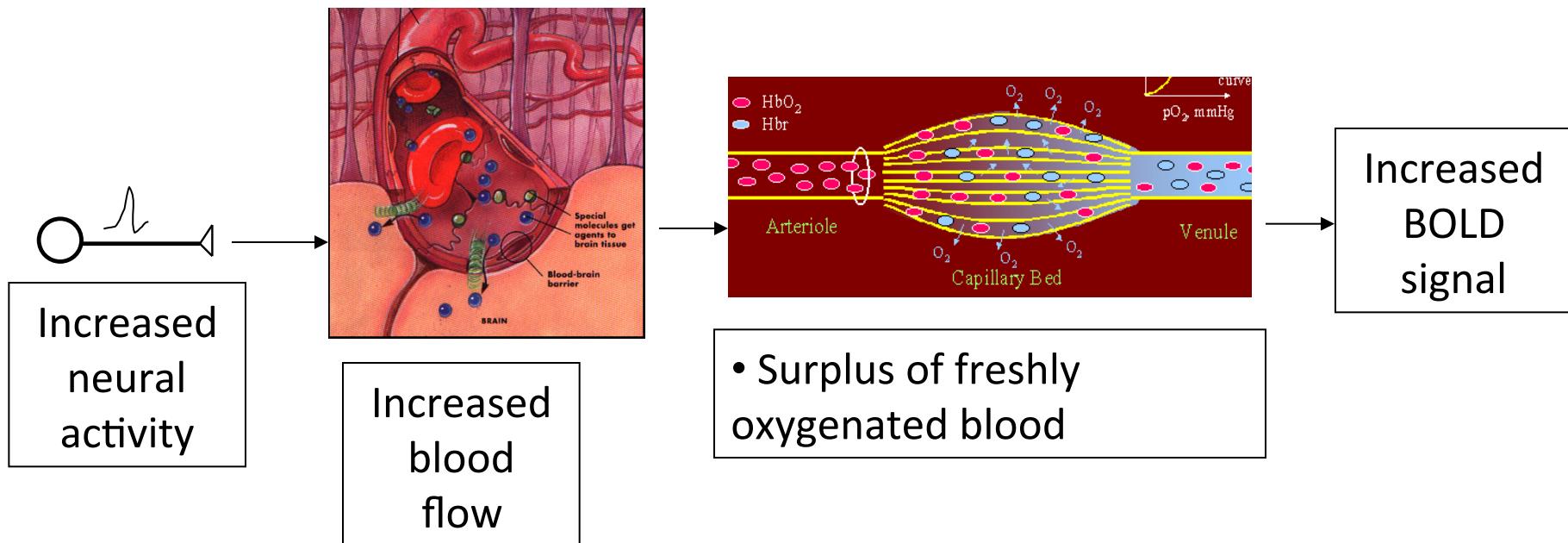
Functional MRI (fMRI)

- Looks at the blood oxygen dependent signal (BOLD)
 - Tracking where the blood is dumping oxygen
 - Blood takes a little while to get to site, so low temporal resolution
 - High spatial resolution



Neural Basis of BOLD

- An *indirect* measure of neural activity
- Based on fact that oxygenated and deoxygenated blood have different magnetic properties



MRI and fMRI

Strengths	Weaknesses
Spatially precise, low temporal, and non-invasive.	For functional scans, signal is relatively slow. Hard to dissociate events that occur nearby in time – difficult to infer causality.
Can look at functional networks of areas over whole brain	Expensive.
Anatomical and functional properties.	Indirect measure of neuronal activity

Which method is best?

- You want to know the *causal* relationship between occipital lobe and vision
- You want to manipulate a deep brain structure non-invasively.
- Does attention affect early perception or late perception?
 - EEG (high temporal resolution)
 - Used for finding when something occurs
- Are faces and houses represented in different areas in temporal lobes?
 - fMRI (high spatial resolution),
 - Used for locating brain regions

Which method is best?

- Does attention affect early perception or late perception?
 - EEG (high temporal resolution)
 - Used for finding when something occurs
- Are faces and houses represented in different areas in temporal lobes?
 - fMRI (high spatial resolution),
 - Used for locating brain regions

Which method is best?

- You want to know the *causal* relationship between occipital lobe and vision
 - Brain stimulation (tDCS, TMS)
 - Imaging studies are correlational only
- You want to manipulate a deep brain structure non-invasively.
 - tDCS – non-invasive and can reach deep structures

Which method is best?

- Does attention affect early perception or late perception?
 - EEG (high temporal resolution)
 - Used for finding when something occurs
- Are faces and houses represented in different areas in temporal lobes?
 - fMRI (high spatial resolution),
 - Used for locating brain regions

Essentials: Intro Cog Neuro

- The critical link between brain and behavior.
 - Early misapplications of this principle!
 - Localizationism vs Holism
- Neuroanatomy: finding your way around the brain
 - Lobes, gyri, sulci, axes, ...
- Major CogNeuro methods
 - Limitations/strengths of each method.
 - Appropriate questions to ask for these methods